PHOTOGRAPH THIS SHEET

ADA083536

DTIC ACCESSION NUMBER

LEVEL

I

INVENTORY

FTD-ID(RS)T-0360-79

DOCUMENT IDENTIFICATION

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

DISTRIBUTION STATEMENT

| ACCESSION FOR | | |
|---|---|---|
| NTIS | GRA&I | ☑ |
| DTIC | TAB | ☐ |
| UNANNOUNCED | | ☐ |
| JUSTIFICATION | | |
| BY | | |
| DISTRIBUTION / | | |
| AVAILABILITY CODES | | |
| DIST | AVAIL AND/OR SPECIAL | |
| A | | |

DISTRIBUTION STAMP

DTIC
SELECTED
APR 24 1980
D

DATE ACCESSIONED

79 11 13 2.0

DATE RECEIVED IN DTIC

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDA-2

DTIC FORM OCT 79 70A

DOCUMENT PROCESSING SHEET

FTD-ID(RS)T-0360-79

# FOREIGN TECHNOLOGY DIVISION

AERONAUTICAL KNOWLEDGE
(SELECTED ARTICLES)

Approved for public release;
distribution unlimited.

# EDITED TRANSLATION

FTD-ID(RS)T-0360-79 5 July 1979

MICROFICHE NR: FTD-79-C-000897

AERONAUTICAL KNOWLEDGE (SELECTED ARTICLES)

English pages: 23

Source: Hang K'ung Chih Shih, Nr. 9, September 1978, pp. 16-21

Country of Origin: China
Translated by: LINGUISTIC SYSTEMS, INC.
F33657-78-D-0618
H. P. Lee
Requester: FTD/SDSY




PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

Table of Contents

# Is Astrogation Possible? (2)

Yi Lin

## How Much Energy Needed For Spaceflight

In the coming few decades, as a result of the advanced development of modern science and technology in such field as atomic energy, electron, optics, metallurgy and high molecular material, the first permanent star explorer would probably be a robot equipped with well developed electric brain. Not only can it automatically complete various missions, but it can also adapt itself to changing circumstances so as to overcome difficulties. Its life span can be as long as a normal human being. Its weight is about 100 kilograms like that of an astronaut with his spacesuit on. However, to accelerate such a light weight explorer to a speed one third of light speed requires as much energy as 1,000,000 million kilowatt hours. Such an amount of energy proximately equals to the total amount of energy generated in a medium size developing country for one year. In fact, however, in addition to the explorer, there are huge structure of space rocket, engine and brake system and they all have to be accelerated to their maximum velocity. The total weight of them altogether is obviously far beyond 100 kilograms, so the energy needed for spaceflight could be hundreds or thousands times more than 1,000,000 million kilowatt hours.

If such huge amount of energy is to be generated by using chemical fuel, like using a match to ignite a hydrogen bomb, it is simply impossible. But

where is the source of such energy? The answer is that it will depend on the conversion of mass into energy. According to Einstein's formula, the relationship between mass and energy can be expressed by the following

Energy = mass x (light velocity)

If the energy of 1,000,000 million kilowatt hours is converted into mass relating to it, the weight of the mass is only about 5 kilograms. This means that consuming mass of 5 kilograms can accelerate a weight of 100 kilograms to a velocity one third of light velocity. Certainly, this seems very inexpensive.

But as of today, the conversion of mass into energy can only partially be realized in the process of nuclear fission and nuclear fusion. In a thermal nuclear engine, the energy converted from the consumed mass can be expressed by jet velocity. Under an ideal condition, if jet velocity can* reach half of ligh velocity, the mass consumed should constitute 14% of total material, and if jet velocity is one third of light velocity, the mass consumed would be 6% of total material. But what can be predicted now is that, in the future, the thermal nuclear energy which has highest conversion efficiency would be the fusion reaction of deuterium into helium. In this conversion, the mass which has been converted into energy is less than 1% of total material, and a part of the energy is lost because it has become heat, so jet velocity can at best reach one twentieth of light velocity. That

* Translator's note: From here till the following page, the translation is made from Chinese text, of which each sentence misses some words when xeroxed.

is 15,000 kilometres per second. This velocity is 4000 times of present rocket jet velocity.

## Jet Velocity and Mass Ratio

For flying to the nearest permanent star, is a jet velocity of 1000 kilometers per second sufficient? In order to answer such a question, we should briefly talk something about the fundamental principles of rocket movement.

The maximum velocity of a rocket is determined by two factors: one is jet velocity and the other is mass ratio. The greater the jet velocity or the greater the mass ratio is, the greater the maximum velocity of a rocket will be. The mass ratio of a rocket is the ratio of its initial weight and its empty weight (weight after propellant has been burned up). This reflects the specific weight of the propellant in whole rocket. The greater the ratio of the propellant is, the greater the mass ratio will be.

So there are two approaches to achieve greater velocity: to increase jet velocity and mass ratio. To increase jet velocity is more important.

When the required maximum velocity is a given value, the greater the jet velocity is, the smaller the required mass ratio will be. Generally, it would be the best if the jet velocity is equal or close to the maximum velocity that the rocket is required to reach. At this point, the required

mass ratio is no greater than 5, and this is relatively easy to achieve. Following the reduction of jet velocity, the mass ratio will probably, according to the rule of index, increase rapidly. For instance, when jet velocity is one twentieth of light velocity and if maximum velocity is expected to reach one half of light velocity, the mass ratio would be as high as 60,000. If maximum velocity is one third of light velocity, mass ratio should be 1,000. All these are simply impossible. Due to the limitation of material strength and technical condition, the mass ratio of single-stage rocket can at most reach a number more than ten. If the total mass ratio of multi-stage rocket can reach 500, that is the peak.

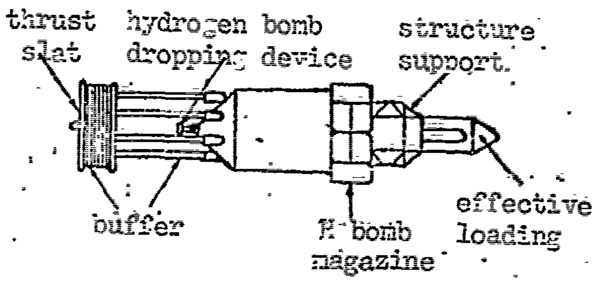
The rocket mass ratio required for reaching various maximum velocity are given as follows when jet velocity is one twentieth of light velocity. From the table, it can be seen that the maximum velocity of spaceflight cannot surpass 30% of light velocity.

| Maximum velocity | 0.1C | 0.2C | 0.3C | 0.4C | 0.5C |
| --- | --- | --- | --- | --- | --- |
| Mass ratio | 7 | 55 | 500 | 4700 | 59000 |

## A Conceptual Design of an Engine for Spaceflight

From the preceeding discussion, we come to know that the key to turn astrogation into a reality is to increase flight velocity, and the key to increasing flight velocity is to promote jet velocity. The jet velocity is determined by an . engine. So, in the last analysis, the key to the realization of astrogation is whether or not a superstrong space engine can be manufactured.

Engine for ε ɪrogation, up to today, is still at the stage of research and planning. Five different kinds of space engine have been suggested.



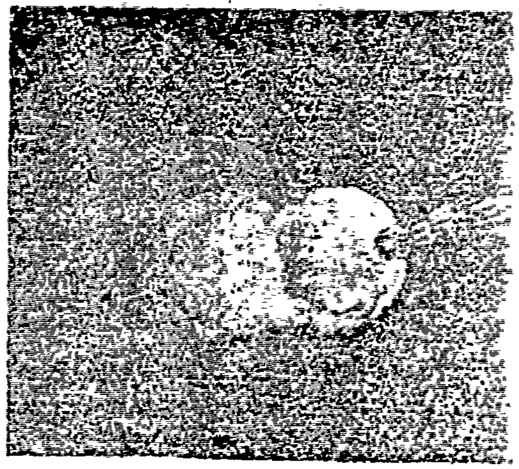



Figure 2 On the left hand side is a diagram of pulse thermal nuclear engine. On the right side is a conceptual picture.

1. Pulse Thermalnuclear Engine

This engine is in fact a series of explosion of hydrogen bombs. The shock wave and particle current produced from the explosion are directed to jet toward a given direction to produce reaction force that is used to propel the space rocket. One of the drawings in Figure 2 is a diagram of pulse thermalnuclear rocket and the other is a conceptual picture.

The total weight of the rocket is 400,000 tons and it carries a space ship of 40,000 tons. 300,000 hydrogen bombs are used as kinetic energy and they are weighted 260,000 tons. The structure of the rocket, thrust slat, hydrogen bomb magazine and dropping device are altogether 100,000 tons.

The explosion of each hydrogen bomb produces power for a velocity of

30 metres per second. The explosion force through thrust slat and buffer enables the rocket to gain continuous and homogeneous 1g acceleration.

In every three seconds, there is a hydrogen bomb exploded and the bombs are enough used for ten days. When the velocity reaches 10,000 kilometres per second (one thirtieth of light velocity), it will take 130 years to reach the half-man half-horse alpha constellation. It is too long. At present, however, among various astrodynamical assumptions, this one should be considered as the most practical one, because the manufacturing, storage and using of hydrogen bombs have proved very successful. Recently, the successful testing of using laser or electron beam which can be close to light velocity to excite hydrogen bomb to achieve very high temperature needed for explosion,has differed any need to use atomic bomb to set off the explosion. Thus the hydrogen bomb can be manufactured as small as a pellet and, as a result, the structure pace rocket can be much smaller.

2. Controlled Thermalnuclear Engine

As of today, the test of controlled thermalnuclear engine has not yet been successful. The main difficult is that the reaction temperature of nuclear fusion can reach several tens of million degrees and there has been so far no container that can stand such high temperature to contain it. In addition, if the plasma gas produced from the reaction reaches the container, the temperature will immediately become low and the reaction stops at once. Because all reaction gas are electrified deuterium and tritium ion, so now the way of containing it by magnetic field is under study. And at the same

time, magnetic field and electric field are tried to produce very high temperature needed for maintaining reaction. This is the so-called "magnetic bottle method". The sealing property of the "magnetic bottle" is not good so there is always a problem of gas leaking. But the leaking gas has its merit in astrogation. The reaction of gas leaking toward a certain direction can produce the expected jet reaction thrust.

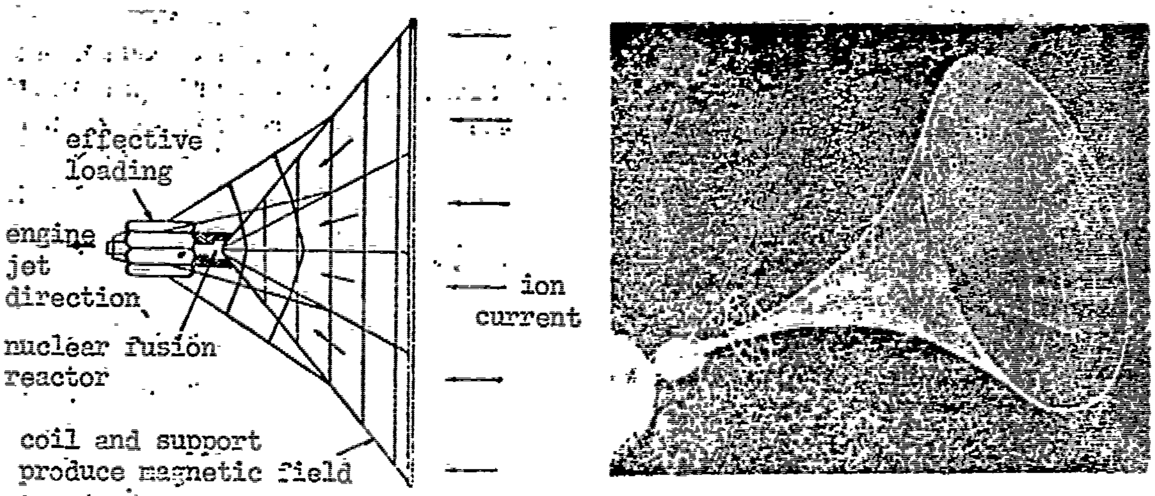



Figure 3 On the left hand side is a diagram of pulsating pressure space engine. On the right hand side is a conceptual picture

Presently most of the studies and assumptions concerning astrogation rest their hopes on the success in testing of controlled thermalnuclear reaction engine. As efforts have been continuously made, it may not be far off from the day that thermalnuclear reaction can be controlled. And the controlled thermalnuclear engine will be the most promising space engine in the futrue.

3. Pulsationg Pressure Space Engine

Because the jet velocity of a controlled thermalnuclear engine is much smaller than the maximum velocity of flight, the mass ratio required by a rocket is quite large. When a space rocket starts its journey from solar system, it must carry several tens of thousands tons of fuel. For solving the problem of over-weight of fuel, a pulsating pressure space engine is now under study. Its characteristic is that it has only one nuclear fusion reactor, and the nuclear fuel--deuterium needed for fusion can be obtained from the space.

The vast space looks empty, but it is not without anything there. The space is full of interstellar matters which are composed of hydrogen ions and atoms, and the density of the interstellar matters is very thin. At the spot where the density is highest, there are no more than 1000 hydrogen atoms per cubic centimetre and the density constitutes 1% of atmosphere density at an altitude of 1000 from the earth. At the spot where the density is small, there is only one hydrogen atom per cubic centimetre. Of the interstellar matter, there is one deuterium ion among each 8000 hydrogen ions. The pulsating pressur space engine is designed to use this part of deuterium as fusion fuel. Because of their thin density, there must be a large intake device to absorb the interstellar matters.

Figure 3 shows a conceptual diagram of an engine of this kind. A space rocket is like a shark in space with its mouth widely open. It swims forward continuously and,at the same time, it tries to catch the interstellar matters with its big mouth. In the front of the engine, there is a funnel-

like big mouth. When it reaches a place where the density of interstellar matters is high, the maximum diametre of the funnel can be 60 kilometres, and where the density of the interstellar matters is low, the diameter of the funnel must maintain as wide as 2000 kilometres. To manufacture a funnel of such magnitude is certainly not easy. The funnel cannot be made of any visible material, as the interstellar matters are always under impact of heating and collision by a velocity of several tens of thousand kilometres per second, the funnel will soon lose its strength and performance if it is made of visible materials. So there can only be a funnel-like magnetic field and the magnetic lines are used to catch hydrogen ions.

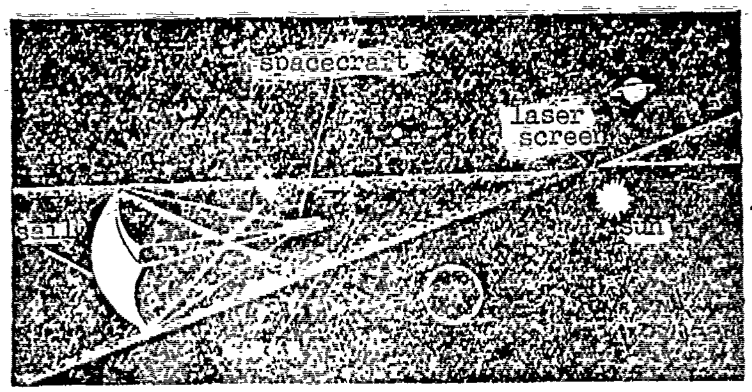



Figure 4 Conceptual diagram of a laser propelled spacecraft

4. Laser Propelling

There will be a pressure when light strikes on a substantial body. Even though such a pressure is insignificant, if the surface that receives the light is large enough, the pressure produced on it by the light can be used to propel a spacecraft.

It has been assumpted that in the interstellar space near to the sun a large laser screen can be built and that the sun can be directly converted into laser (see Figure 4). The diametre of the laser screen must be as large as 250 kilometres, otherwise, the light beam will mostly disperse when it reaches the distance of 4-6 light year. There is a huge sail on the spacecraft to receive the rays of laser, and the diametre of the sail must also be 250 kilometres. The sail is made of very thin and very light material and it must be reflective to any light so it can catch the maximum light pressure. The weight of the sail is estimated no less than 1000 tons.

When the spacecraft is not far away from solar system, it can use a laser screen of which the diametre is ten kilometres as power source.

The plan of using laser directly to propel a spacecraft seems to be a wishful thinking. But due to the fact that it does not have to have complicated nuclear reactor installation and, on the other hand, it can save tens of thousands tons of fuel, the plan has caught wide attention. A more practical plan as mentioned above is to use laser beam as power source, and thermanuclear fuel to excite nuclear fusion to produce jet thrust.

5 Antimatter Engine

According to the law of antithesis and unity in dialectics, in the objective world, where there is matter there is antimatter opposite to it. The discovery of antipostive, antiproton and antineutron lend support for the existence of antimatter.

When matter and antimatter interact with each other, as what Einstein formula has pointed out, total mass will be converted into energy. The energy will emit in the form of ray, neutrino, high-energy electron and others*. One half of the energy cannot be used because it is quickly absorbed by neutrino, and still there is other small part is lost because it has become heat. Jet velocity can be augmented to reach one fifth of light velocity. In order to enable the maximum velocity of spaceflight to reach one third of light velocity, mass ratio must be 6. Antimatter only constitutes 2% of the weight.

In a huge high-energy accelerator, anti-proton can be produced by using strong proton bombardment of one hundred billion protons. Each year only a few kilograms of matters used for high-energy physical test. The 21th century will be the earliest when it becomes enough to be used as propellant. What is more difficult is the storage of anti-matter. So the realization of antimatter engine remains to be a new challenge to the modern technology.

We have introduced some situations of astrogation among permanent stars, the plans of spaceflight and the conceptual design of space engine. In fact the difficulties in astrogation are much more than these, such as the guidance and communication are all problems to be solved. In the following issue we shall talk something about the process of astrogation.

* Hereafter each sentence of the original Chinese text misses some words

What is Degree of Freedom

De Xing

In an article describing gyroscope in previous issue of this journal, a term "degree of freedom" appears frequently. Our reader Meng Lin from Peking and Yung Xi from Nanking write to us and ask for an explanation of the term. In order to enable our readers to understand the term, we ask Comrade De Xing to give an explanation as follows.

The term "degree of freedom" in the study of gyroscope refers the freedom of mechanical movement of a body in space. That is the degree of free movement of a body in space. As we know that movement is an inseparable property of a matter and is a form of existence of a matter. Mechanical movement is a position change of a matter in space and time. When we study mechanical movement of a body, we always start with an already known basis of reference—coordinate system to observe the mechanical movement of the body relative to this coordinate system, namely the relative movement. For instance, when we study the movement of a plane, a car or a train, we often take the earth as reference basis, then we observe their relative movement to the geographical coordinate system. Thus we know that the degree of freedom is directly related to the selection of coordinate system. A plane in the sky (see the picture on left hand side of Figure 1), for example, can fly freely toward east, west, south or north and up or down, and the range of its free movement is very great. But a car running on the ground (see the picture on right hand side of Figure 1) is limited by the surface of

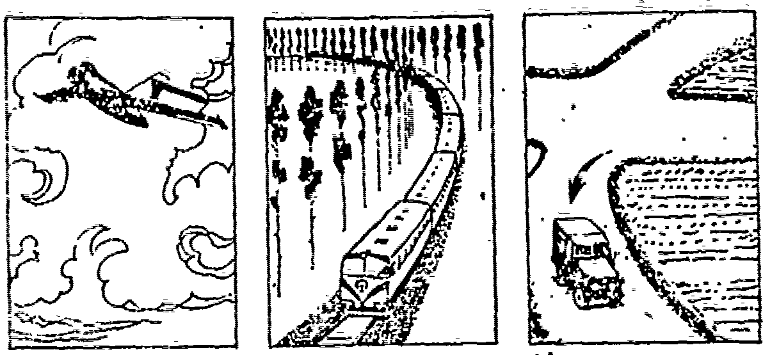


Figure 1 A comparison of the degree of free movement
of some moving bodies

the ground. It can run toward east, west, south or north but it cannot lift up from the ground nor can it enter into the ground, namely it cannot like a plane go up or down. So the degree of its free movement is smaller than a plane. Again for example, when a train is running on its track (see the center picture of Figure 1), in addition to that it cannot run up or down because the limitation of the ground, it cannot be away from the track to run freely toward any direection. So the degree of its free movement is smaller than a car. Hereby we can see that the freedom of mechanical movement of a body is limited by external forces.

The freedom of a plane in flight is so great that the forms of its movement become complicated. How to study the movement of a plane? According to the principles of theoretical mechanics, we know that although the movement of a body can be of various forms, the movement, however, can be basically classified into two categories: moving and rotating. In order to make a clear explanation, we take the movement of a body on a plane , as illustrated in Figure 2, for example. When a body moves from its initial

position to a new position, the fixed line AB will following the movement of the body turns into A'B'. As to the question of how the body moves to its new position, we do not have to discuss it here. However, for the study of its movement, we should take two steps: First step is to let the body move horizontally toward a right downward direction, then A will coincide with A' (the dotted line position in Figure 2). The second step is again to let it rotate around A' forming an angle θ, it can coincide with the new position of the body. This means that however complicated the movement of a body can be, the motion can only be classified into moving and rotating, two basic movement.

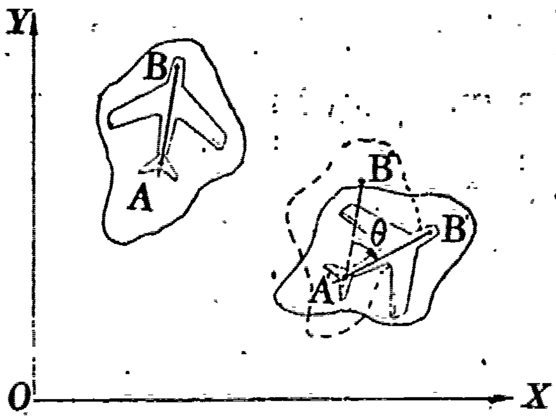



Figure 2 Analysis of the movement of a body on a plane

Certainly, the complicated movement of a plane flying in the sky can as well be classified into two parts: moving and rotating. In study, usually an adequate OXYZ right angle coordinate system is selected as reference, such as earth based coordinate system. The moving part is explained by using the change of the coordinate value x, y and z of the plane gravitation C, and the rotating part is explained by using the change of rotation angle $\psi, \gamma$ & $\theta$ .

Using a right angle coordinate system to obsreve and study the movement

of a plane while it is flying freely in the sky, we can summarize the freedom of the numerous movements of the plane into six: three moving freedom and three rotating freedom. What should be pointed out with emphasis here is that in the study of movement of a body, the coordinate systems selected are different, and the freedom of movement will be different, too. For instance, if an earth-based coordinate system is selected to observe the movement of a train along a flat and straight track, its freedom of movement is only one, but, if a galactic inertial coordinate system is selected to observe the train, it can have six degrees of freedom.

The movement of many objects can be considered as having six degrees of freedom. But for some specific objects, they have less than six. For example, the freedom of movement of a car running on the ground is less than a plane flying in the sky, nontheless, it can be regarded as an object of which the degrees of freedom in movement are six, for the road cannot be absolutely even so it has up and down movements. Moreover, a car can make turns and in each turn there is an inclination, so it has three rotating degrees of freedom. But in an actual analysis, emphasis is given to two moving degrees of freedom and one rotating degree of freedom as it can rotate around the earth perpendicular line, so it has altogether three degrees of freedom. Certainly this makes the study methods simpler.

When we analysize a gyroscope, the gyroscope should be said to have six degrees of freedom because it is used in a flying vehicle. The freedom of the flying vehicle is also the freedom of the gyroscope. But in the study

of a gyroscope, generally only its three rotating degrees of freedom with practical value are emphasized. What should be pointed out is that in the study of a gyroscope, the degree of freedom refers only to the rotating freedom in space. The so-called three-freedom gyroscope means, in the true sense, that a gyroscope has three rotating degrees of freedom. At present, there are different ways to talk about the freedom of gyroscope. One is to consider the rotation of the rotator, so it is called three-freedom gyroscope. When one of the three is restrained, it is called two-freedom gyroscope. The other is not to consider the rotation of the rotator, so it is called two-freedom gyroscope. When one of the two is restrained, it is then called signle-freedom gyroscope. The bottom line is how to use the concept of freedom when the movement of a specific object is analysized.

The Principles and Application of Solid-state Pressure Transducer

Chen Ruo-yu

In aviation industry and science research, techniques of pressure measurement are widely applied. The attainment of parametres of flight altitude of an aircraft, air speed indication, Mach number and landing speed all deppends upon the principles of pressure measurement. The accurate measurement of gas burning pressure, oil pressure and pressure ratio of inlet channel and exhaust channel of an aircraft engine is a prerequisite for the reliability of an engine working under optimal condition. Such pressure measurements are indispensable in flying vehicle modeling, engine ground testing, simulation test in high altitude and so are in atomic energy industry and fuel chemistry industry.

As a result of continuous advancement of industries, the requirement for pressure measurement becomes higher and higher. Becuase a pressure transducer is the key part of pressure measurement techniques, to manufacture new pressure transducer of small size with high precision has become a very urgent task. Especially in aviation, it has become an item of first priority.

The scope of pressure measurement is rather broad, and the types of transducer which is used to sense pressure are numerous. Before the advent of solid-state pressure transducer, the transducers which are used to measure pressure are mostly "mechanical type" or "electromechanical type". The mechanical type pressure transducer usually uses compound film,

corrugated tube or end-sealed tube sensing pressure to produce displacement and stress, which are then amplified by an amplifier, and finally the reading of pressure is indicated on a disk on which the number of degree is carved. The electromechanical type pressure transducer is on the mechanical type set up electrified converting uints, namely through electric elements such as electric potential metre, electric induction or electric capacity convertor, microinching synchronizer and self-adjusting angle controller to convert mechanical displacement and stress into electric signals such as electric resistance, electric induction, electric capacity, voltage and electric current to put out.

The size of this kind of transducer is generally very large and the accuracy is poor. The friction of the rotating amplifying mechanism and the non-linearity make measurement error constituting probably 1-10% of the measured pressure. This cannot meet the requirement for transducer used in science research nor is it suitable for aviation industry.

In the sixties, a comprehensive unit of flight parametres -- atmosphere data computing system is used in aircarfts. But the key problem is till how to have a pressure transducer with high precision. For solving such a problem, many new transducers of various types have been manufactured in recent years, such as electromagnetic induction transducer, compound* resonance transducer and piezoelectric or piezoresistance transducer. Among

* Hereafter and a large part of the following page , each sentence of the original Chinese text misses some words.

them the piezoresistance transducer, namely the single film pressure transducer, is also called solid-state transducer.

Solid-state pressure transducer is the silcon film pressure transducer, which is made of solid material—signle crystal silcon.

The structure of this kind of transducer is that the pressure sensing elements are films made of single crystal silcon. The diameter of the film is small (1-20mm) and its thickness is thin (0.2-0.5mm). The silcon film is made by way of cutting according to crystal direction. Through processes of grinding and polishing, the film surface is made very smooth and even. So the film is a crystal plane of a single crystal silcon. Then through fine semiconductor working process, on the film surface along its crystal direction, electric resistance lines are engraved. Figure 1 shows a film with crystal surface and crystal direction

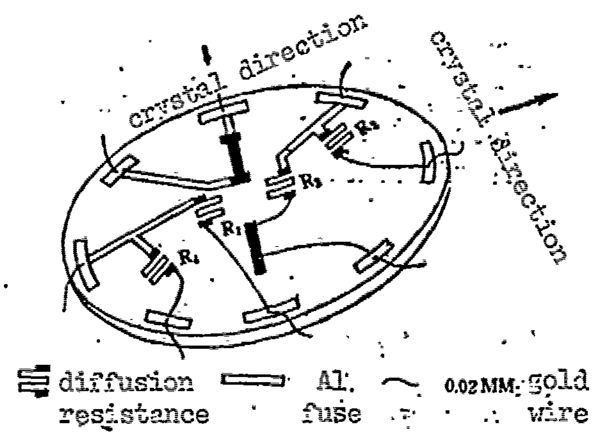



Figure 1 A film with crystal direction and crystal face

The functions of sensing pressure and converti signals of this transducer are performed by silcon film and there is no neer to have the rotating amplifier mechanism like an electromechanical pressure transducer has. To extend in meaning of the concept of "solid-state element" in electron industry, this transducer is designed as well as manufactured by applying both the theory of solid-state physics and the techniques of semi-conductor integrated circuit. It is therefore called solid-state pressure transducer.

## Single Crystal Silcon and "Piezoresistance Effect"

Single crystal silcon is the silcon of which the crystal lattice is regularly permuted. It is different from multi-crystal silcon. It has same electric conduction rate at each direction. From experience we know that the piezoresistance effect of this kind single crystal silcon is very obvious. When anyone who wants to utilize piezoresistance effect to make article often selects this material.

What is piezoresistance effect? From phenomena we can see that this kind of effect is expressed in the diffusion resistance of silcon film when different degrees of external pressure is added, and its resistance value will change correspondingly. This is piezoresistance.

The diffusion resistance on silcon film is created by using the semi-conductor technique as mentioned above, and on silcon film they are individual resistance. Diffusion resistance value is determined by technical factor

and geometrical form of resistance stripes.

What must be pointed out is that temperature has greater effect on diffusion resistance. That is the primary reason that the error occurrence on this kind of transducer is more often. The degree of the effect of temperature is determined by the concentration of inclusion infiltrated in the diffusion resistance. So here it is clear that to select appropriate inclusion concentration can compensate the temperature effect and improve accuracy of the transducer.

We have previously stated that the sensitive element of the transducer to sense pressure is a film with fixed boader. Usually the ratio between diameter D and thickness h of the film is 20 ~ 60. To analysize the stress distribution of the film under the action of pressure is a problem of "thin-plate mechanics".

It would be very useful if we come back to review Figure 1. A group of resistance (R1 and R3) locates in a pulling stress zone on the film and they face the center of the film symmetrically. Another group of resistance (R2 and R4) locates in the pressing stress zone and they also face the center of the film symmetrically. When there is an action of external force, these two groups of resistance begin to have action stress of different direction. Because there is piezoresistance effect, we can have the alternating quantity of postive and negative opposite resistance. Consequently, the output

signal of the bridge is augmented.

Of course, the position of resistance on the film must be along the crystal direction of which the piezoresistance coefficient is great.

The merits of solid-state pressure transducer are salient, such as small size, light weight, reliable performance, simple structure, less stagnant phenomenon and its accuracy can be one quantity level higher than other pressure transducers for same purpose. So it has created favorable condition for application to the digit technique of parametre comprehensive measurement in flight. Therefore it has caught great attention and interest of concerned sections in the country and abroad. But, however, the high degree of precision of a solid-state pressure transducer is not easy to achieve at all. Primarily because the sensitivity of semiconductor material to temperature is too strong, even a change of temperature by one or only half degree, the transducer will react. As we know, the environmental conditions of aviation product are very poor, so the key point is how to make appropriate temperature compensation to guarantee the precision of the transducer. Otherwise, the accuracy of the transducer will become low. In addition, the technical stability of aviation product remains to be a problem. If there is no satisfactory solution, it will become a main factor of unstable performance, thus its application to aviation measurement will be limited. However, in the future, as a result of rapid development of electron industry and successive break-through in technical difficulties,

and more advanced studies of semiconductor, various kinds of ideal solid-state pressure transducer will certainly be produced.

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

| ORGANIZATION | | MICROFICHE |
|---|---|---|
| A205 | DMATC | 1 |
| A210 | DMAAC | 2 |
| B344 | DIA/RDS-3C | 9 |
| C043 | USAMIIA | 1 |
| C509 | BALLISTIC RES LABS | 1 |
| C510 | AIR MOBILITY R&D LAB/FIO | 1 |
| C513 | PICATINNY ARSENAL | 1 |
| C535 | AVIATION SYS COMD | 1 |
| C591 | FSTC | 5 |
| C619 | MIA REDSTONE | 1 |
| D008 | NISC | 1 |
| H300 | USAICE (USAREUR) | 1 |
| P005 | DOE | 1 |
| P050 | CIA/CRS/ADD/SD | 2 |
| NAVORDSTA (50L) | | 1 |
| NASA/NST-44 | | 1 |
| AFIT/LD | | 1 |
| LLL/Code L-389 | | 1 |
| NSA/1213/TDL | | 2 |

| ORGANIZATION | | MICROFICHE |
|---|---|---|
| E053 | AF/INAKA | 1 |
| E017 | AF/RDXTR-W | 1 |
| E403 | AFSC/INA | 1 |
| E404 | AEDC | 1 |
| E408 | AFWL | 1 |
| E410 | ADTC | 1 |
| | FTD | |
| | CCN | 1 |
| | ASD/FTD/NIIS | 3 |
| | NIA/PHS | 1 |
| | NIIS | 2 |